Elements of
Military Sketching

ELEMENTS of MILITARY SKETCHING

ARRANGED FOR USE OF THE ORGANIZED MILITIA OF VERMONT

By

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Fifth U. S. Infantry

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PREFACE.

The diagrams herein were executed by Sergeant W. Weidenbach, Company "K", 5th Infantry, to whom credit is also given for valuable assistance in originating and preparing the text.

The publication of this pamphlet was undertaken with a view of supplying a simple and short treatise devoted exclusively to the important subject of Military Sketching. While intended, primarily, for the use of the Organized Militia of Vermont, it is thought that it may be of value to the militia of other states.

Elements of Military Sketching.

MAP SCALES.

1. A *map* is a graphical representation of a portion of the surface of the earth. A *map* is made with the proper survey equipment and is supposed to be accurate. A *sketch* is as nearly an accurate map as can be made by field drafting with the time and instruments available, and frequently with restricted reconnaissance.

Distances on a map have a fixed proportion to distances on the ground represented.

In order to read or make a map it is, therefore, necessary to know the proportion, or ratio, existing between any given map distance and the actual ground distance represented by it. This ratio is expressed by means of *map scales.*

The principle of scaling is that one unit of any length on the map represents a certain number of like units on the ground.

2. This ratio existing between map distance and ground distance may be expressed in three ways:

(1) In *words and figures,* as: 3 inches = 1 miles.

(2) By what is known as "REPRESENTATIVE FRACTION"—a fraction, the numerator of which shows units of length on the map, while the denominator shows the corresponding distance on the ground, thus:

Representative Fraction, (R. F.) $\frac{1}{21120}$, means that one inch, or one unit of any measure on the map, represents a distance of 21120 inches, or units of that measure, on the ground.

If the scale of a map were 4 inches to the mile, then 4 inches (map) would represent 63360 inches (mile) on the ground,

$$\text{or} \quad \frac{4 \quad \text{(map-dist.)}}{63360 \quad \text{(ground-dist.)}}.$$

As the R. F. is usually written with numerator unity, we would have:

$$\text{R. F. } \frac{4}{63360} = \text{R. F. } \frac{1}{15840}$$

Emphasis is laid upon the fact that R. F. is internationally used; this circumstance enables us to readily determine the scale of foreign maps in inches to the mile.

(3) The scale may be represented *graphically.*

A graphical scale is a plotted line of certain length to represent a given ground distance.

Instead of writing 3 inches = 1 mile, we may draw a line three inches in length and mark it 1 mile. Subdivisions of this line represent shorter distances and are marked with their respective values.

The scales of American (military) maps are:

1 inch (approximately) to the mile, or R. F. $\frac{1}{62250}$ (Geological Survey Maps):

3 inches to the mile, or R. F. $\frac{1}{21120}$ (Scale generally used for road sketches and area maps).

6 inches to the mile, R. F. $\frac{1}{10560}$ (Scale used for position sketches.)

12 inches to the mile, R. F. $\frac{1}{5280}$ (Scale used for fortification-plans, war game maps, etc.)

Less frequently used are the scales 2 inches to the mile, (R. F. $\frac{1}{31680}$) and 4 inches to the mile, (R. F. $\frac{1}{15840}$).

CONSTRUCTION OF GRAPHICAL SCALES: A first requirement in map-making or map-reading is a knowledge of scales. Assume that a map has R. F. $\frac{1}{21120}$ (3 in. = 1 mile) but no graphical scale. In order to measure off any definite distance on the map it is necessary to have a graphical scale of 3 in. to the mile. This scale may be constructed as follows: Draw a line 3 inches long; this line, representing one mile, should be divided into 1760 equal parts—each part representing 1 yard—but as such division can scarcely be made without special instruments, a division into $17\frac{6}{10}$ parts is sufficient. Each subdivision then represents 100 yards ground-distance.

In constructing this, or any scale, a simple method, based upon a principle of plane-geometry can be advantageously followed, viz:

"If an angle is cut by a series of parallels, the corresponding segments of the legs of the angle are proportional."

The angle B-A-C is cut by parallels; thus proportional divisions are produced on both legs of the angle. (Diagram 1).

In Diagram 1a, A-B is three inches, the length of the desired scale. To divide A-B, a fixed line, into $17\frac{6}{10}$ parts, we simply divide A-C, a line of indefinite length, into $17\frac{6}{10}$ parts, and draw parallels through the division-marks on A-C to A-B.

The advantage of this method is that *the divisions on A-C can be of any convenient length.*

EXAMPLES.

Let us assume the scale of a map to be 4 inches to the mile,

(R. F. $\frac{1}{15840}$). A graphical scale is desired.

We know that four inches represent 1760 yards.
Select a more convenient number of yards as 1000, 1600, 2000, etc. We can solve the problem by proportion; if 4 inches represent 1760 yards, how many inches represent 1000 yards?

$4 : 1760 :: x : 1000 . \quad x = 2.27.$

A line 2.27 inches in length is drawn and divided into equal parts, using parallels as in Diagrams 1 and 2.

In this case A-C may be 2½″ long. Divide A-C into ½ inch lengths from your ruler and draw parallels from these points through A-B. A-B is then divided into 200 yard lengths. By estimation, or parallels, subdivide the left extension to read smaller distances, and erase line A-C and parallels.

Similiar proportions can be formed with any convenient number of yards as given ground-distances.

The scale can also be computed as follows:

R. F. $\frac{1}{21120}$ that is, 3 inches = 1 mile (1760 yards).

$1 \text{ inch} = \frac{1760}{3} = 586 + \text{yards.}$

A graphical scale 3 or 4 inches long is desired.

Select a convenient number, as 2000 yards.

If 586 yards are represented by 1 inch, how many inches represent 2000 yards?

$\frac{2000}{586} = 3.4 \text{ inches.}$

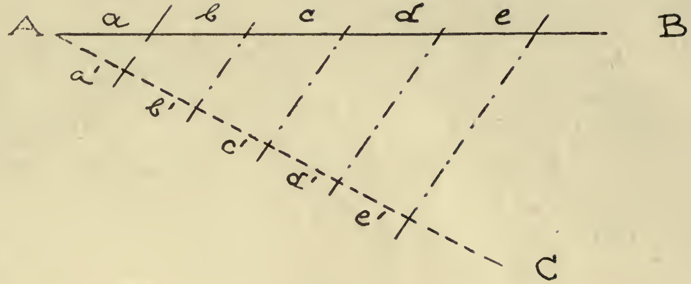
4. The scale reading yards, meters, miles, etc., usually found on a completed map is called *"reading-scale."* When making a map, however, a so-called *"working-scale"* is necessary. In making military maps, particularly road or position sketches, the distances on the ground may be measured by pacing, taking the time of a horse's trot, counting telegraph-poles with reference to their interval, counting revolutions of a wheel, by speedometer, odometer, etc. In any case it will be necessary to have a "working-scale"—that is, a scale of the units employed in measuring the distances.

The units of the "reading scale" have a fixed and standard value such as yards, meters, miles, etc., while the units of any "working-scale" used in making a map depend upon the individual and the means at hand for measuring distances. The working scale does not appear on the completed map.

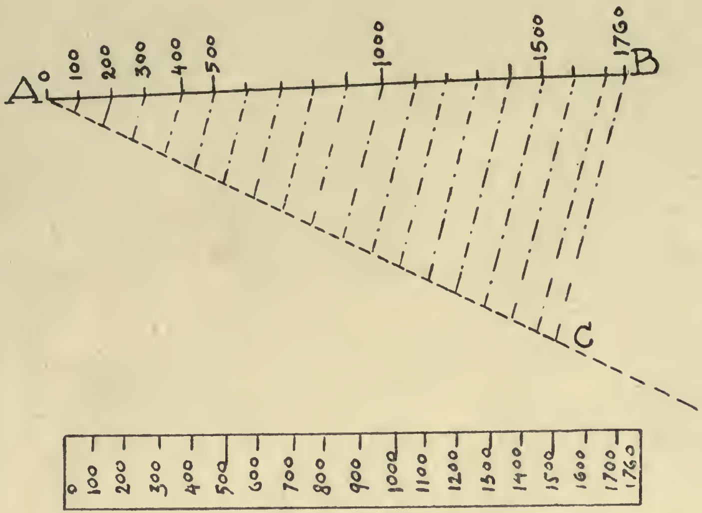
It is desired to make a road sketch 3 inches to the mile, distance measured by pacing. Assume the stride of the mapper to be 60 inches. He will cover 100 yards with 60 strides. To construct the working-scale, we use the same method employed in constructing a reading-scale, but changing the value of the scale-divisions as expressed in yards to the corresponding number as expressed in strides or paces, thus; 100 yards = 60 strides. 120 strides = 200 yards, etc. (It is advantageous to combine the working-scale with reading scale, as in Diagram 3.)

This scale would usually be computed as follows:

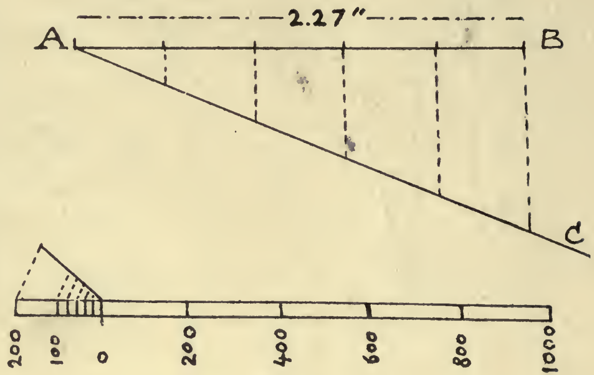
1 stride = 60 inches; $\frac{63360 \text{ (1 mile)}}{60} = 1056$ strides to the mile, hence 3 inches represent 1056 strides.



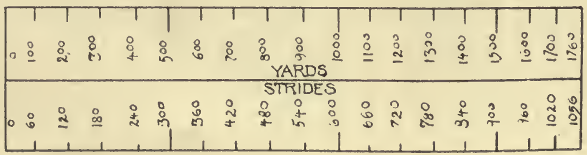
Diag. 1.



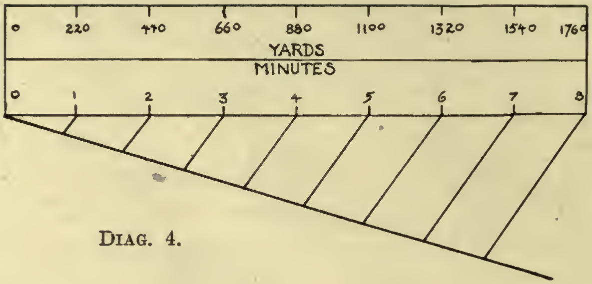
Diag. 1a.



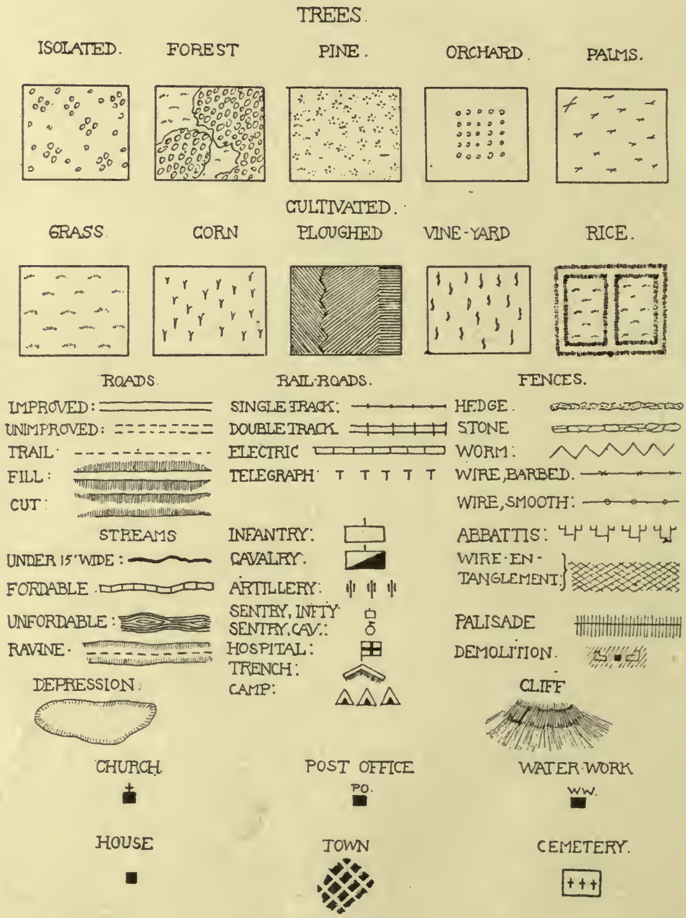
Diag. 2.



Diag. 3.


0
220
440
660
880
1100
1320
1540
1760
YARDS
MINUTES
0
1
2
3
4
5
6
7
8

DIAG. 4.


TREES.
ISOLATED.
FOREST
PINE.
ORCHARD.
PALMS.
CULTIVATED.
GRASS.
CORN
PLOUGHED
VINE-YARD
RICE.
ROADS.
IMPROVED:
UNIMPROVED:
TRAIL:
FILL:
CUT:
RAIL-ROADS.
SINGLE TRACK:
DOUBLE TRACK.
ELECTRIC
TELEGRAPH:
FENCES.
HEDGE.
STONE
WORM:
WIRE, BARBED.
WIRE, SMOOTH:
STREAMS
UNDER 15' WIDE:
FORDABLE
UNFORDABLE:
RAVINE.
DEPRESSION.
INFANTRY:
CAVALRY:
ARTILLERY:
SENTRY, INF'TY
SENTRY, CAV.:
HOSPITAL:
TRENCH:
CAMP:
ABBATTIS:
WIRE-EN-TANGLEMENT:
PALISADE
DEMOLITION.
CLIFF
CHURCH.
POST OFFICE
P.O.
WATER WORK
W.W.
HOUSE
TOWN
CEMETERY.

DIAG. 5.

3 : 1056 : : x : 1000 . $x = 2.84''$.

Suppose by actual experiment over a measured course, a horse has been found to trot a mile in 7 min. 40 sec. Then 7 ⅔ min. = 1760 yards. We desire to make a working scale 3″ to the mile. Take 10 min. as a convenient number. Then 3 : 7 ⅔ : : x : 10. $x = 3.9''$. Construct a scale 3.9 inches long divided to read the fraction of a minute desired.

As these data vary with the individual and the means used it is, therefore, necessary to determine carefully the length of the measuring unit before making the working scale.

When preparing a working-scale for pacing, much attention should be given to determining correctly the length of the pace in inches. In testing the number of paces over a measured course, the gait and length of step should be natural. A measured course of 100 yards may suffice, but a mile course over an undulating road will give more accurate results. The mean of several trials will give still greater accuracy.

The same applies to a scale of minutes. By careful tests it must be ascertained how many minutes a horse requires to cover a given distance at a trot or walk.

The average horse covers one mile in 8 minutes at a trot, and in 16 minutes at a walk. (Diagram 4).

(NOTE)—Prepared Working Scales of any length of pace, or minutes of a horse trotting can be obtained at a nominal cost from the Book Department, Service Schools, Ft. Leavenworth, Kans.

CONVENTIONAL SIGNS.

5. The purpose of a military map is the graphical representation of ground with constant reference to probable military use. It should, therefore, not only be true in regard to distances and directions, but should also give a comprehensive picture of the condition of the ground as to cultivation, geological formation, and other features of military interest, as railroads, telegraph lines, bridges, etc. Consequently it has been necessary to invent characteristic graphic signs, (called *Conventional Signs*), to represent all objects of military importance, and the form of the ground itself.

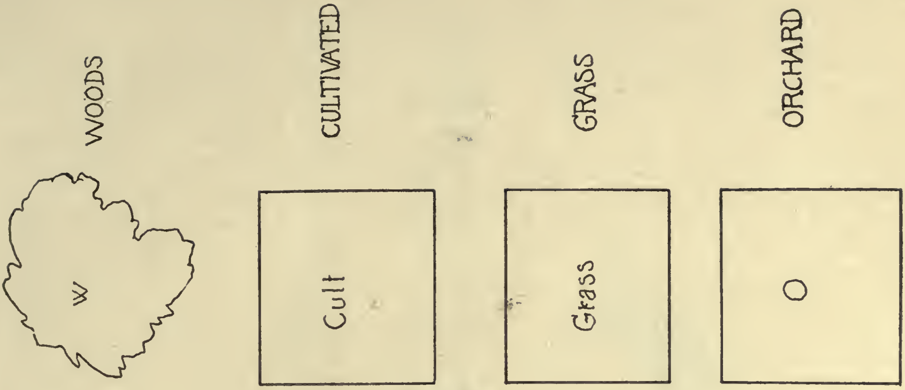
The more common conventional signs used in military topography are given in Diagram 5.

Many of these conventional signs are used only in elaborate topographical work. For hasty sketching, (road or position-sketches), the simplified conventional signs as given on pages 209 and 210, Appendix C, Field-Service Regulations 1910, answer all purposes. Grass, trees, cultivated land, woods, etc., are therein more simply represented by drawing the outline of the particular feature and placing inside the appropriate symbol or letter, (Diagram 5a). This method is recommended in all reconnaissance or hasty sketching.

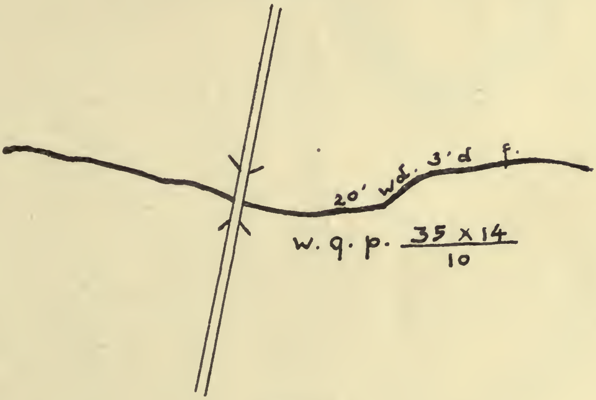
Diagram 6 indicates the character of stream, span and construction of the bridge. (Stream 20 feet wide, 3 feet deep and fordable. Wooden queenpost post bridge 35 feet long, 14 feet wide and 10 feet above the water.)

"The following abbreviations are authorized for use on field maps and sketches. When these words are used they must be written in full or abbreviated as shown. The abbreviations must not be used for words other than those in the table. Words not in the table are not as a rule abbreviated". (F. S. R. 1910).

abut.	abutment	P.O.	postoffice
B.S.	blacksmith shop	Pt.	point
bot.	bottom	Q.	quarry
Cr.	creek	q.p.	queen post
cul.	culvert	R.	river
cult.	cultivated	R.H.	round house
d.	deep	R.R.	railroad
E.	east	S.	south
f.	fordable	s.	steel
gir.	girder	S.H.	school house
G.M.	gristmill	S.M.	saw mill
i.	iron	Sta.	station
I.	island	st.	stone
jc.	junction	str.	stream
kp.	kingpost	tres.	trestle
L.	lake	tr.	truss
Mt.	mountain	W.T.	water tank
N.	north	W.W.	water works
n.f.	not fordable	W.	west
p.	pier	wd.	wide
pk.	plank	w.	wood

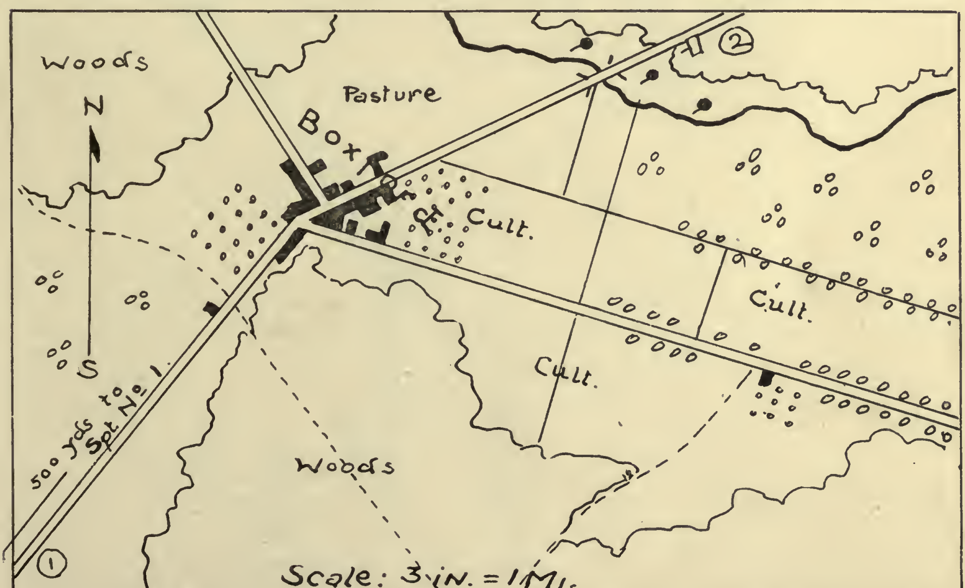


DIAG. 5a.

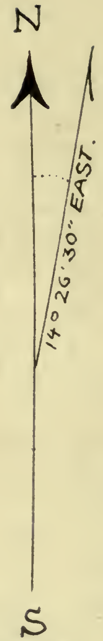


DIAG. 6.

EXAMPLE OF RECONNAISSANCE SKETCH.

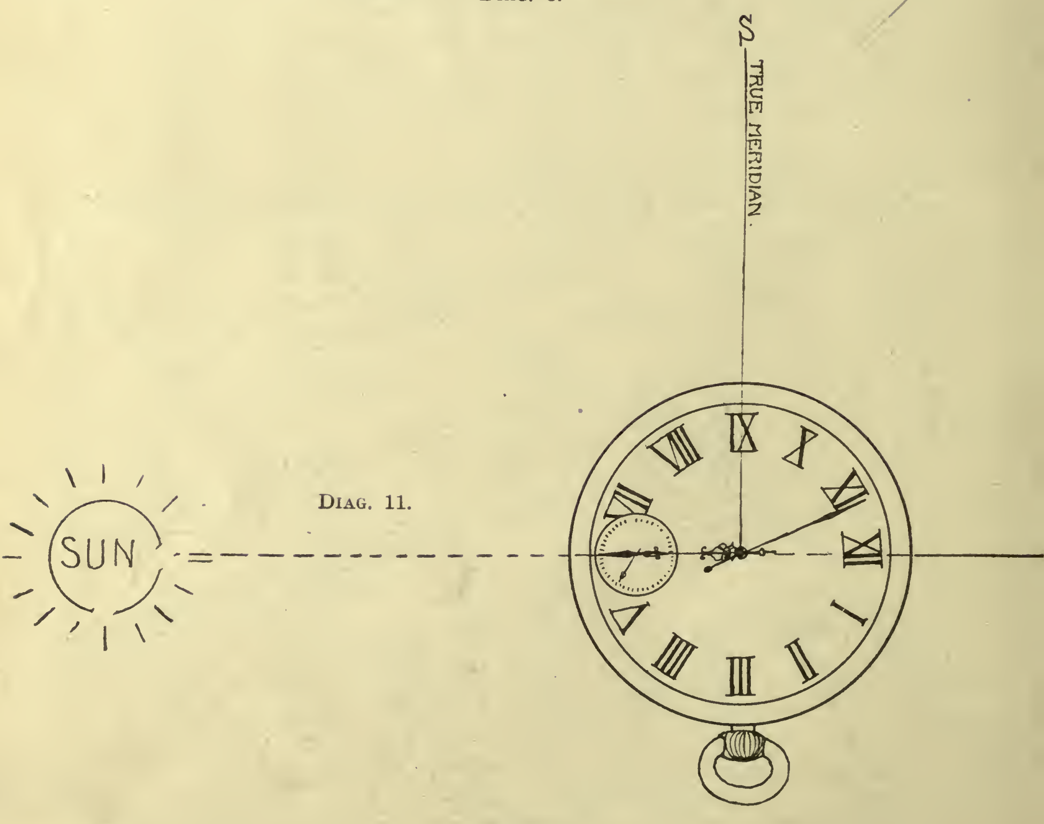


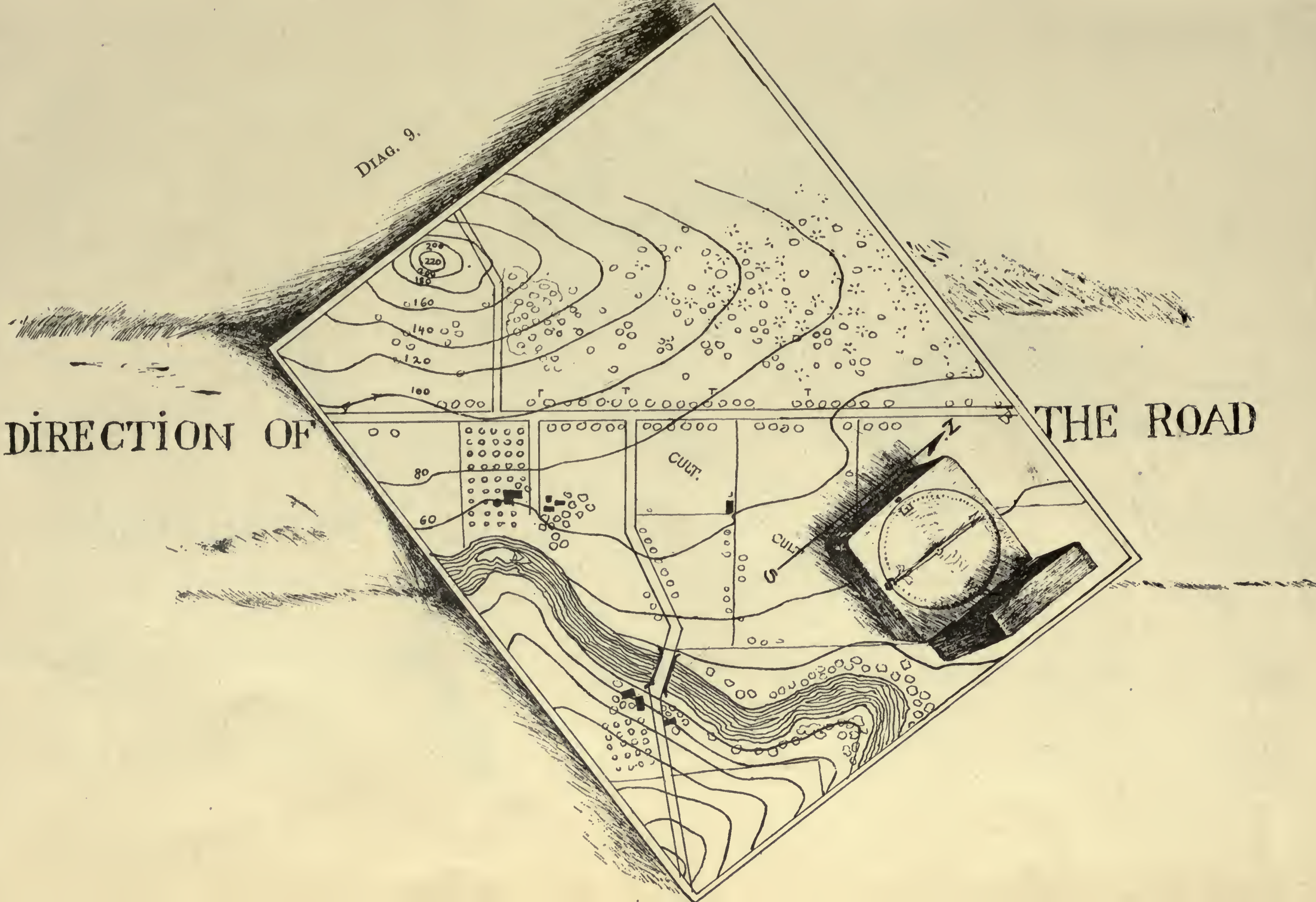
DIAG. 7.



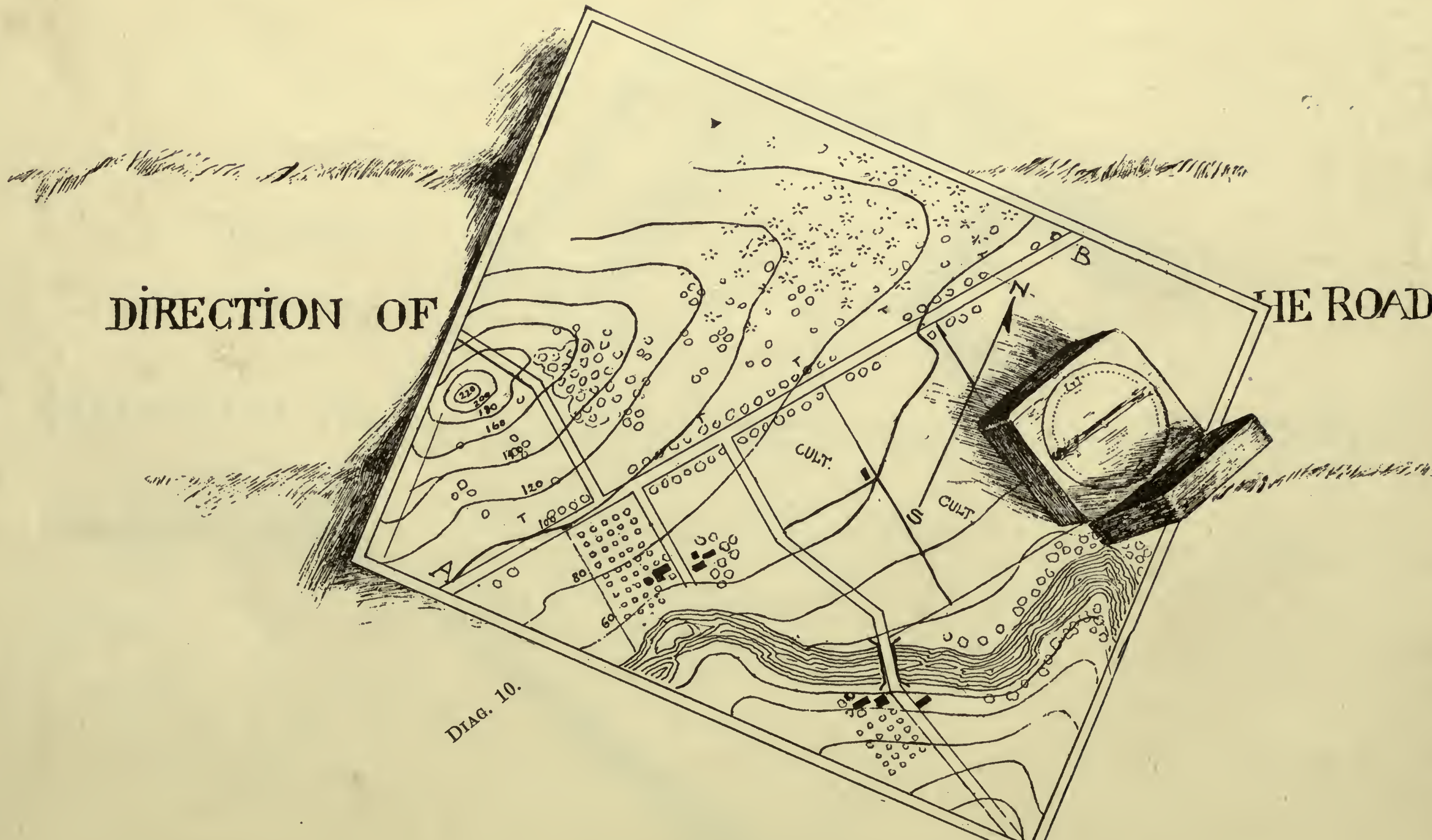
Diag. 8.

Diag. 11.




DIRECTION OF THE ROAD
220
200
180
160
140
120
100
80
60
CULT.
CULT.
N
S

Diag. 9.


DIRECTION OF
HE ROAD
B
N.
S
A
CULT.
CULT.
220
200
180
160
140
120
100
80
60

DIAG. 10.

ORIENTATION.

6. ORIENTATION is placing the map in its true relation to the ground represented; in general, the location of any point in relation to the north and south of the map as determined by the magnetic needle.

As a rule maps have a north and south line.

It should be known, however, that the compass-needle does not in all localities point true north, but usually varies several degrees East or West. This is called "magnetic variation" (deviation, declination).

Consequently there may be two direction-lines on a map, the "true" north and the "magnetic" north. (Diagram 8.)

In this instance the magnetic needle has a deviation of 14° 26′ 30″ East from the true north or true meridian.

The true meridian lies in the direction of the North Pole. It is a datum-line, a constant, whereas the N. & S. Line as indicated by the compass-needle is variable because of magnetic influences, depending on the locality and the time. The magnetic meridian is usually represented by a spear, one side of the point of which is missing, while the true meridian is represented by the spear with point completed.

To orient oneself it is only necessary to bring the magnetic North of the map to point in the same direction as the north end of the compass needle and then the bearings of lines on the map and corresponding lines on the ground will be the same. That is, lines on the map will be parallel to the lines on the ground represented.

In Diagram 9, a road A-B is plotted on the map; the magnetic N. and S. line is indicated. You are standing on the road and desire to orient the map. Place the compass on the map so that the line marked N. and S. on the dial is parallel to and agrees with the direction line on the map. Turn the map (without disturbing the position, on the map, of the compass box) until the north end of the needle points towards N. The map is now oriented, and A-B on the map has the same direction as the road on the ground.

Diagram 10 illustrates, that, if the compass-needle and the direction line on the map do not coincide—no coincidence in the direction of the roads is obtained, and the map is not oriented.

The true meridian can be determined by means of a watch, as follows: Place the watch face up with the hour hand pointed towards the sun. A line midway between the hour hand and the number XII will lie in the direction of the true meridian. The north and south ends of this line are evident from the hour of the day and the position of the sun. (To bring the hour hand in the direction of the sun, hold a straw perpendicularly between the sun and the watch, and bring the hour hand in its shadow.) (Diagram 11.)

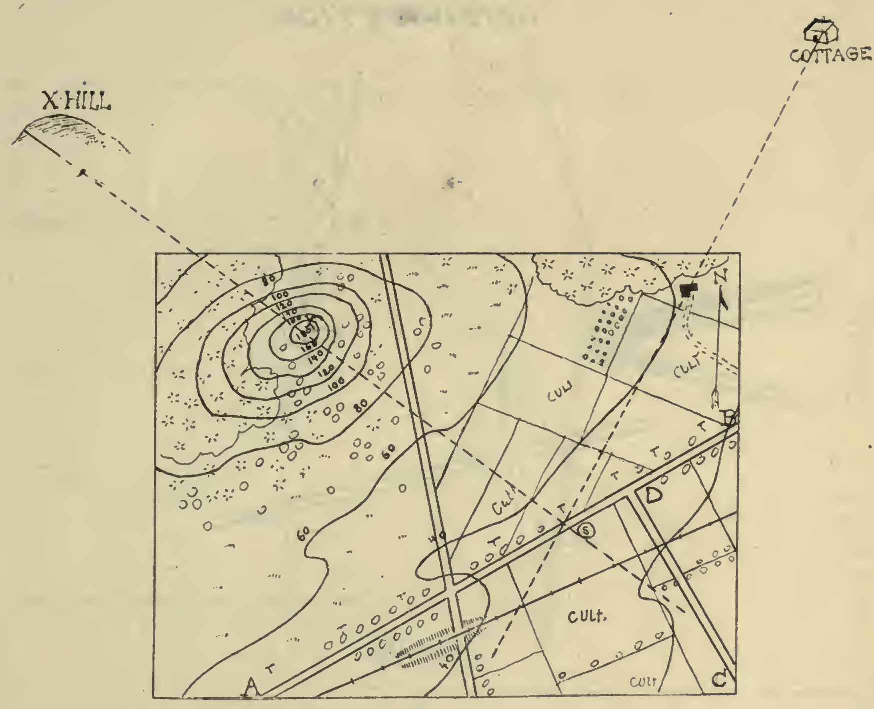
With the true meridian on the map the magnetic declination of the compass-needle can be ascertained as follows: Bring the N. & S. line as indicated on the compass-face to coincide with the true meridian, map oriented. The compass-needle will then be found to vary several degrees to the East or West of the true meridian line. This deviation varies from 0° to 25° in the United States.

RESECTION AND INTERSECTION.

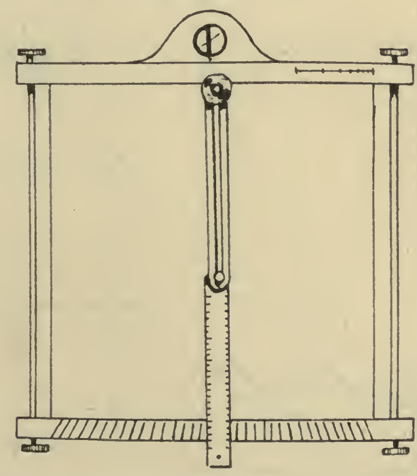
7. RESECTION is a method of locating unknown points by taking the bearings of two or more given points. (Diagram 12).

We think we are on some point of the road A-B, and we want to locate our exact position. Facing B, we have two distinct landmarks on our left, the top of hill (X) and the cottage in front of the pine-wood, both of which we can locate on our map and identify on the ground. Keeping the map oriented, we sight towards the hill until a point (X on the map) and the actual top of the hill are in the same line of sight. We plot the line of sight by drawing a back line through X across the road. This line, obtained through connecting three points (top of hill, X, ourselves), would sufficiently locate our place on the map if we were sure to be on the road A-B. In order to ascertain this, a second similar sight is taken on point Y (cottage) and the line of sight plotted in the same manner. Both lines of sight will cross at a certain point. The point of intersection locates our exact place on the map, as we are on the line S-X, and also on the line S-cottage.

8. INTERSECTION is the same principle applied to locate



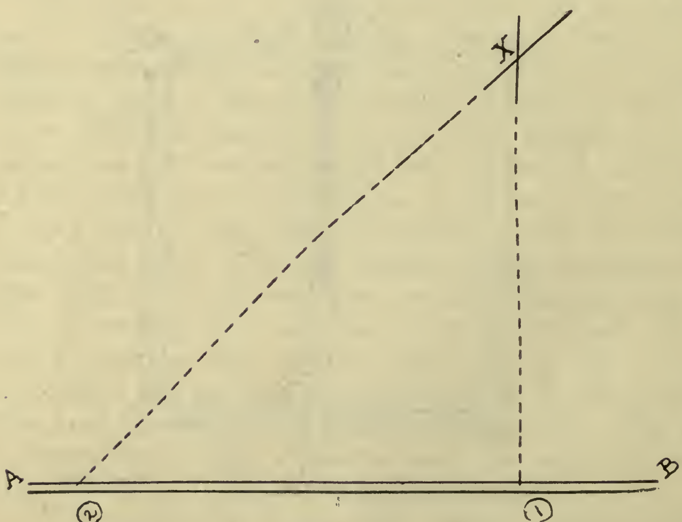
DIAG. 12.



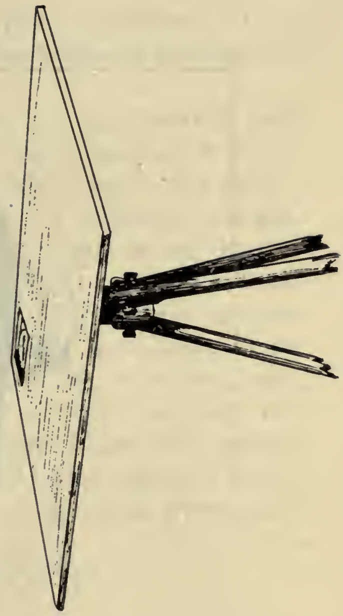
DIAG. 15.

INTERSECTION

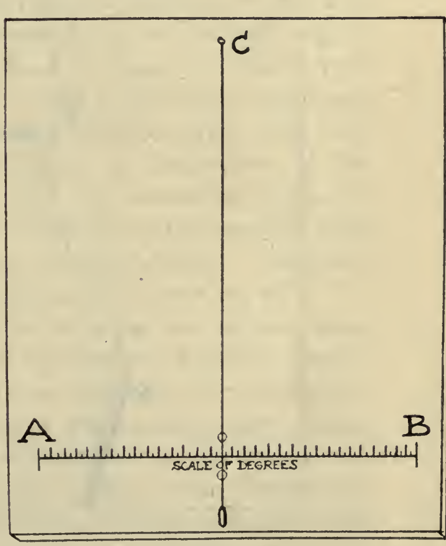
Diag. 13.



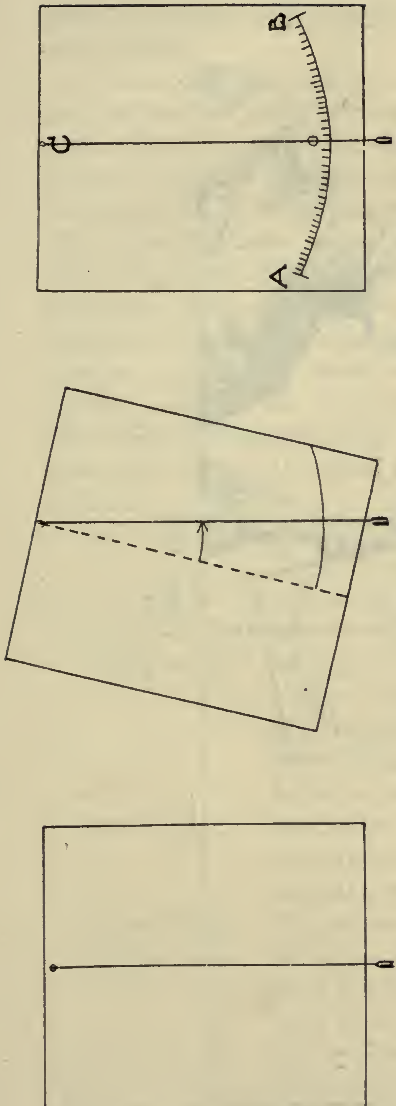
Diag. 14.



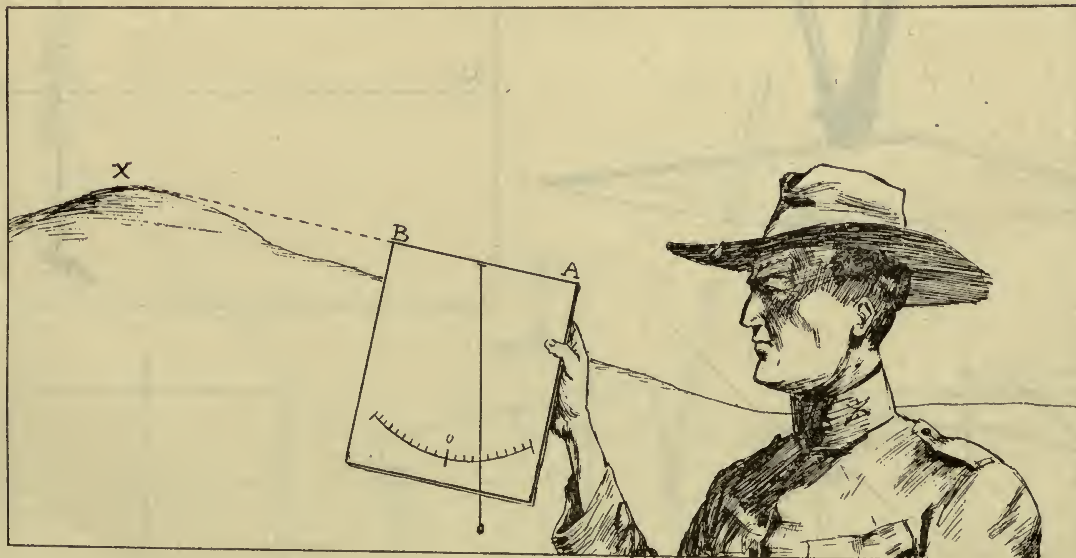
DIAG. 16.



DIAG. 17.



DIAG. 18.



DIAG. 18a.

and plot points situated off the course of the topographer. (Diagrams 13 and 14). Intersection is used in both map reading and map making.

You are on the road B-A, (Diagram 14), and desire to plot an object several hundred yards off the road. Stop at any point of the road (as 1), orient the sketch and sight towards this object, plotting the line of sight by drawing an indefinite straight line from your position towards the object. After having marched a certain distance (as at 2) a second sight is taken and the line of sight plotted in the same manner. This will intersect the first line. The point of intersection locates the object. This method is very accurate provided the base-line is correct; care should, therefore, be taken to measure and plot correctly the distance between the first point of sighting and the second. The smaller the angle at X the greater will be the chance of error. Therefore, this angle should approach a right angle when practicable.

SKETCHING IMPLEMENTS.

9. **Cavalry Sketching Case** (Diag. 15.) A drawing board with a compass set in. The paper is tightly rolled over two metallic rollers on opposite ends of the board. An arm with a brass scale (3 inches to the mile) is fastened to it, freely moving around a pivot. This arm with the graduations on the bottom of the board is also used for measuring slopes in the manner described below, the movable ruler taking the place of the pendulum. The graduations are for slopes of from $1°$ to $20°$.

Plane-Table (Diag. 16.) A good device for mapping, is a simple *plane-table,* (a smooth board about 16 inches square) with a compass set in. Slopes are measured with some form of hand level or slope board, and in taking bearings the board is kept oriented by means of the compass or by "backsighting." The paper is held in place by thumb tacks. The board is fastened to a tripod. A modification of this device, always available, is a smooth board or stiff card board about

12″x12″, without tripod, and a loose box compass. A ruler, paper, thumb tacks, pencil and scales complete the equipment. Under service conditions, hasty sketching will usually be done with such an improvised plane table. Any paper that will stand erasing is suitable; tracing paper is very good. HH to HHHH pencils are generally used, except with tracing paper when B or HB pencils are preferable. When sketching by pacing, a pace tally for registering paces or strides is convenient. When sketching mounted, a stop watch should be used.

SLOPE-BOARD. (Diag. 17. 18 and 18a.) The slope-board is a simple device for measuring degrees of slope. The essential part of the slope-board is a pendulum registering every change of level. It is constructed as follows:

Suspend a small weight on a string, thus forming a crude plumb line and bob. Attach the free end of the string to the middle point of one edge of a rectangular board (the drawing board.) If this edge of the board be kept uppermost and level the plumb line, or pendulum, will hang perpendicularly, and will thus bisect the board. Mark a point O on this bisecting line near the bottom. If the level of the upper edge of the board is disturbed by sighting, the pendulum will *appear* to move forward or back of O. This apparent course of the pendulum (A-B, Diagrams 17 and 18) is a sector that can be divided into degrees. In the diagrams, from C to the line A-B is assumed to be 5, 7 inches, and the divisions on A-B are 1-10 inch apart. Each division on a slope board so constructed will read an angle of 1°.

To use, sight at the object along the edge (top) of the board, at an elevation on the object of about 5 ft. (height of the eye) and read the degrees registered by the pendulum. (Diagram 18a.) Forward is a minus and backward a plus elevation. It is usually more convenient to use both hands in sighting and to hold the plumb line against the board with the left thumb when it is turned to be read. The slope-board should be constructed on the reverse side of the drawing board.

The Locaters Hand Level is a practical and handy slope measuring instrument especially designed for use of sketchers. (Diagram 18b). It can be used as a hand level and clinometer or gradienter at a single observation. When the tube is level an object on a line with the base of the locaters' level object glass is—5°. Thus, in the figure, the observer sights the top of the barn, as 0° (level) and at the same time can see that the eaves of the barn are—1°, and the base of the barn is—3°, being on a line with the third graduation below the center, observing the bridge—5°, which is the limit of the field. But an object outside the field can still be measured in vertical angle. To measure the vertical angle to the foot of the tree:—disregard the bubble, hold hand level so that an object which is—5° (as the bridge) is seen at the top of the object glass, and observe the number of degrees between the bridge and the foot of the tree; in this case it is the whole field of the tube or 10°, hence the base of the tree is—15°.

The locaters' level is made with three separate graduations: degrees, grade in per cent, and in mils (for artillery.) (For sale by the U. S. Cavalry Association, Fort Leavenworth, Kans).

SCALE of the units of measure:—This scale if not prepared by the individual, can usually be purchased at a trifling cost. (If pacing a scale of *strides* should be used.)

SCALE of M. D.

A TRIANGULAR RULER, with the scales pasted on it, facilitates plotting and sighting.

BOX-COMPASS. (Diagram 19)—A simple box-compass is preferable for the beginner. The graduations may be clockwise from 0° to 360°, contra-clockwise from 360° to 0°, or in quadrants from 0° to 90°. A compass graduated contra-clockwise (i. e. in reverse order of the graduations on the face of a clock) is the better as it reduces chances of error in plotting with a protractor.

Attention is invited to the arrangement of the cardinal-points on the dial of the box-compass in Diagram 20. Note that E is to the left of N. This reversion of East and West has been made purposely. A compass with a dial so lettered is more convenient for reading directions. As an example, let us assume the course of a road to be North and then turn to North-West. In the first instance the position of the magnetic needle will be as in Diagram 21. The road then turns to N-W (Diagram 22.) We sight along the edge of the compass-box in the new direction. The needle leaves N and moves toward W (on the dial). We take the reading from N to the needle,———degrees N-W.

The change of direction has really been N - W. If a reversion of the cardinal-points E and W had not been made, the reading would obviously be more difficult, and it is very probable that the sketcher, while working rapidly, would have read—degrees N-E if this reversion of E and W were not shown.

ROAD SKETCHING—WITH A DRAWING BOARD (PLANE TABLE) OR SKETCHING CASE. (DIAGRAM 23.)

10. The starting point is marked (1), [station one]. With the beginner all changes of direction should be similarly marked; with more practice all such data can be omitted.

The needle of the compass is allowed to settle over the North and South line indicated by letters N and S on the compass-face. (If a drawing board with no compass *set in* is being used, lay a box-compass on the board); hold the board steadily so as to allow the needle the least possible swing. (To be exact, the needle should be absolutely immobile; this, however, is hardly to be accomplished without a tripod, unless the board is laid on the ground).

The needle being settled, draw a line parallel to it. Mark the north end.

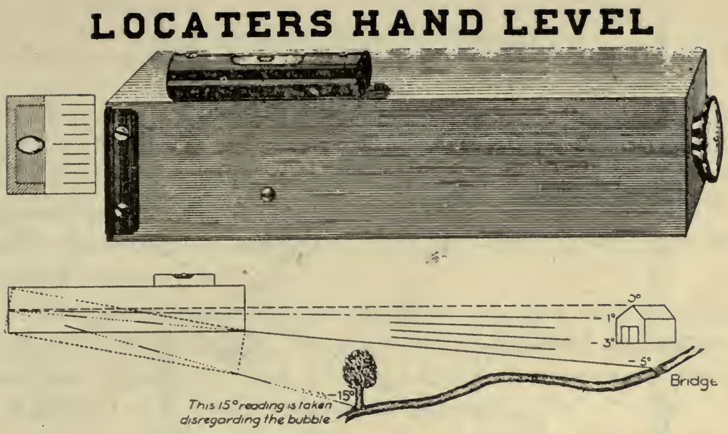
This line is the N. & S. line (meridian) of the map, and with reference to this line all further directions are determined.

Plot the starting point on the paper. Keeping the needle parallel with the plotted map-meridian (N & S. Line), sight along the ruler in the direction of the road by moving the ruler, [using station (1) as a pivot], until it and the road are in the same line of sight. Draw an indefinite line forward along the ruler while holding it firmly in place with the other hand.

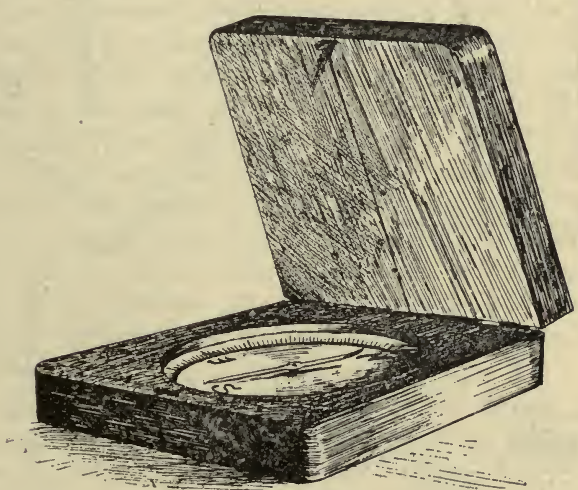
Step off with the *right* foot, counting the strides, and plotting the distances to scale.

When a change of direction occurs, stop, orient the board, and plot the new direction line.

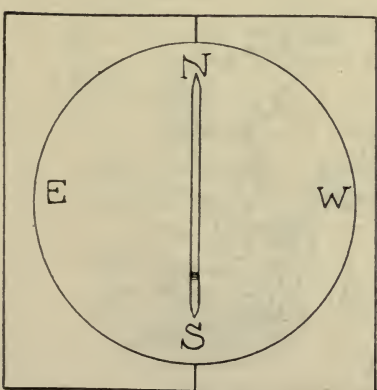
Observe carefully the "lay" of the ground. Plot houses, woods, telegraph-lines, etc., etc.



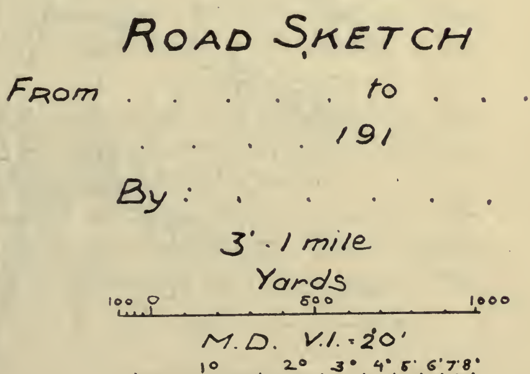
DIAG. 18b.



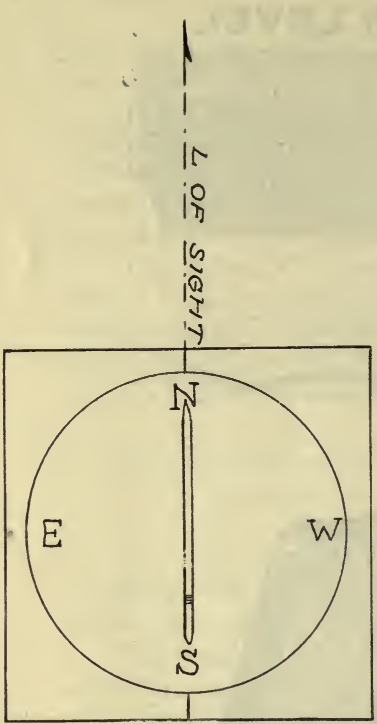
DIAG. 19.



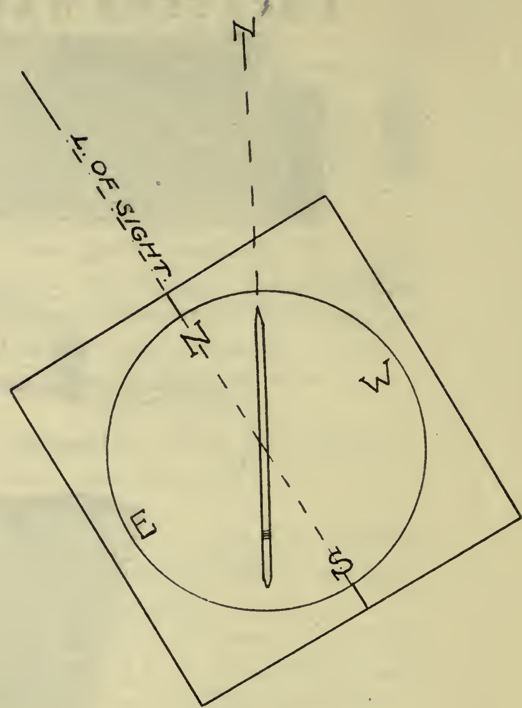
DIAG. 20.



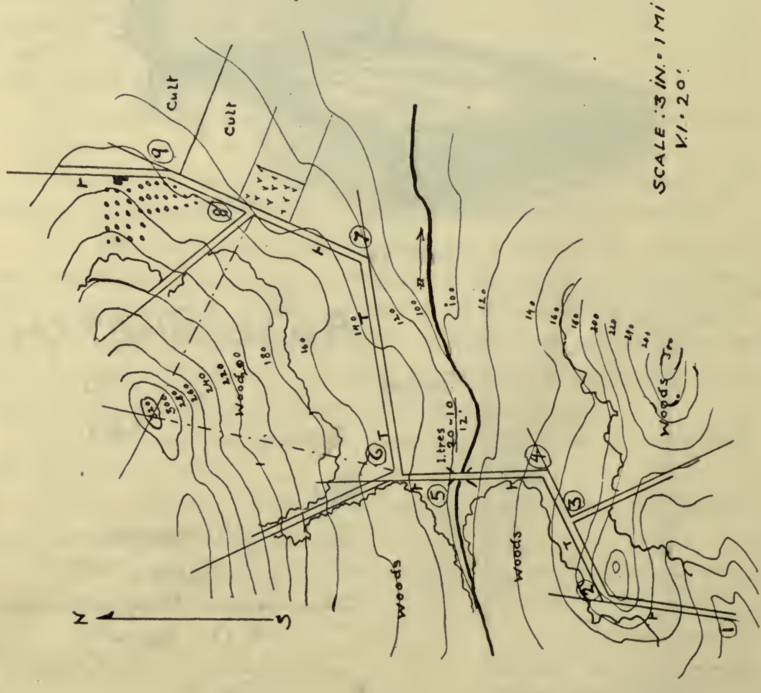
DIAG. 24.



DIAG. 21.



DIAG. 22.



DIAG. 23.

It is customary to take in all military details within three hundred yards of the road traversed, and conspicuous landmarks, high hills, etc., by intersection or estimation to greater distances, depending on the object of the sketch. Cuts, fills, railroad embankments, etc., should never be overlooked as they may have tactical value.

In traversing it is not necessary to halt and plot each feature as it is reached. A note can be made of the distances and the features "plotted in" when it becomes necessary to halt on account of a distinct change of direction.

For example, starting from (1), carefully orient your board, draw an indefinite straight line toward (2) and then pace (or otherwise measure) the distance without halting to plot, having made notes en route of the location of the woods to the right and left; at (2) lay off the distances by scale and complete the sketching to that point. Then stand in the middle of the road (board oriented) and sight towards (4); at (3) it will be necessary to halt to get the direction of the side-road. Now pace to (4) and in laying off this distance, lay off the whole number of strides from (2). If, for example, you have had 260 strides from (2) to (3) and 230 strides from (3) to (4), in plotting (4) lay off the whole distance 490 strides from (2). This method lessens the accumulation of errors arising in taking distances from your scale.

At (4) sight towards (6). Halt at the stream to get its direction, and the data for the bridge. Continue in this manner. [Contouring methods will be explained later.]

If taking strides, count every time the left foot strikes the ground, and be careful that hundreds are not gained or lost.

During each sight the board must be kept *oriented*. This may be done by means of the compass, or by backsighting on the last station.

Telephone—or telegraph—wires or other metal objects, deflect the compass needle, and this cause of inaccuracy must be guarded against when sighting or orienting the board.

The hill 320 is located by intersection. Sight on the hill from station (6), plotting the line of sight; take a second sight from (7) or (8) or (9) and plot the line of sight. The point of intersection of the two lines of sight locates the object on your paper.

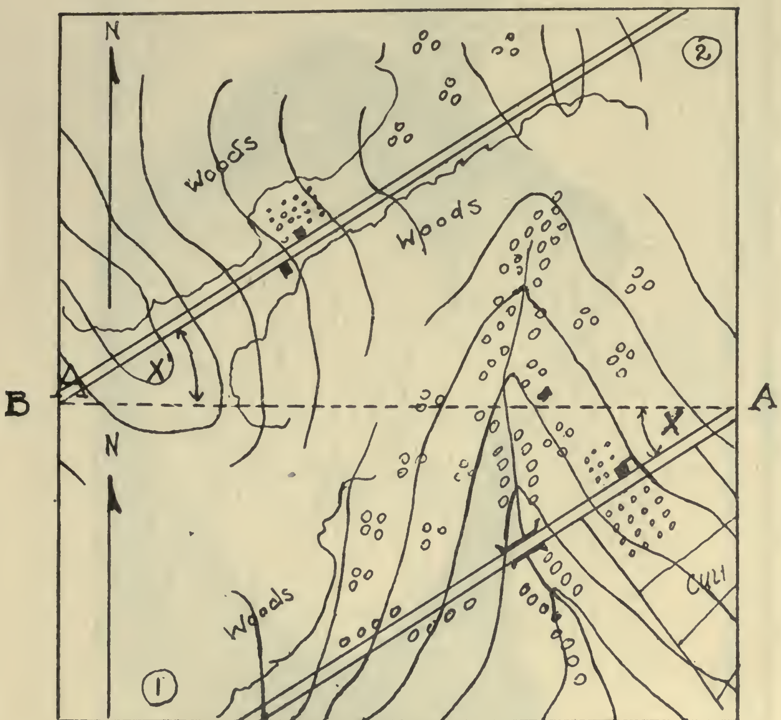
11. In road sketching, it often happens that a change of direction causes the plotting to run off the paper. (Diagram 25.) Draw a cross-line at right angles to the edge of the paper, cutting the point where the plotting runs off (A-B, Diagram 26.) By plotting the angle X′ on B-A, we would have the direction of the road, because X′ and X are opposite angles and equal. The usual way, however, is to select the point A′ (which is the same point on the road as A) at any convenient place on the paper with a view of continuing the sketch; then *plot a new north and south line and begin a new sketch.* If the general direction of the route is known, the starting point on the paper should be selected with a view of getting as much of the sketch as possible on that sheet. To this end the board should be so oriented that the longer axes of the paper will be in the general direction of the route to be sketched.

We may thus have a series of sections of the same route. Number these sections in sequence. They may be put together by pasting the several sections together, or on a new sheet in their proper order.

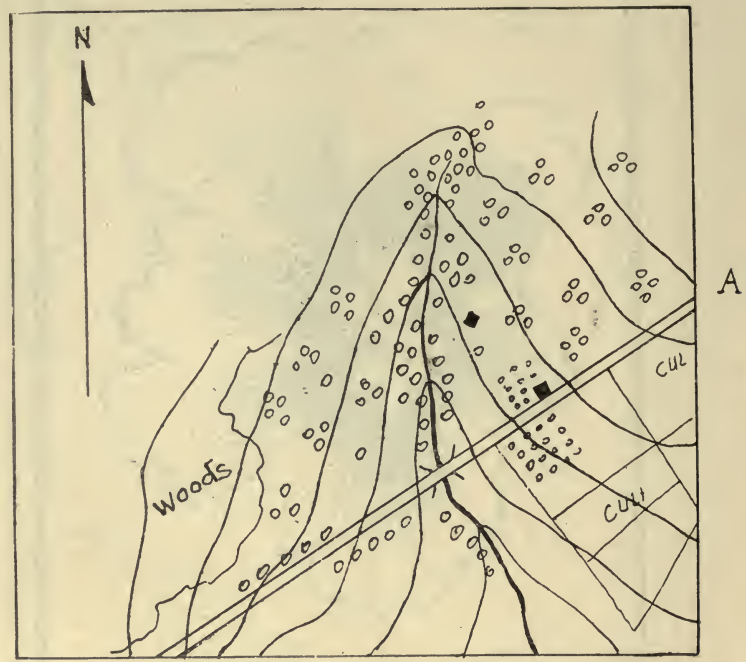
In diagram 26, the sketch (2) is a continuation of sketch (1). When putting the sections together point A′ is laid on point A, *care being taken to keep the meridians of all sections parallel.*

After completing the sketch a simple "legend" or title, is added to the plotting, describing route, scale, vertical interval, etc., etc. (Diagram 24). Written titles will answer all purposes, though printing is generally used. The Reinhardt system of printing, as in the diagram, is most easily acquired.

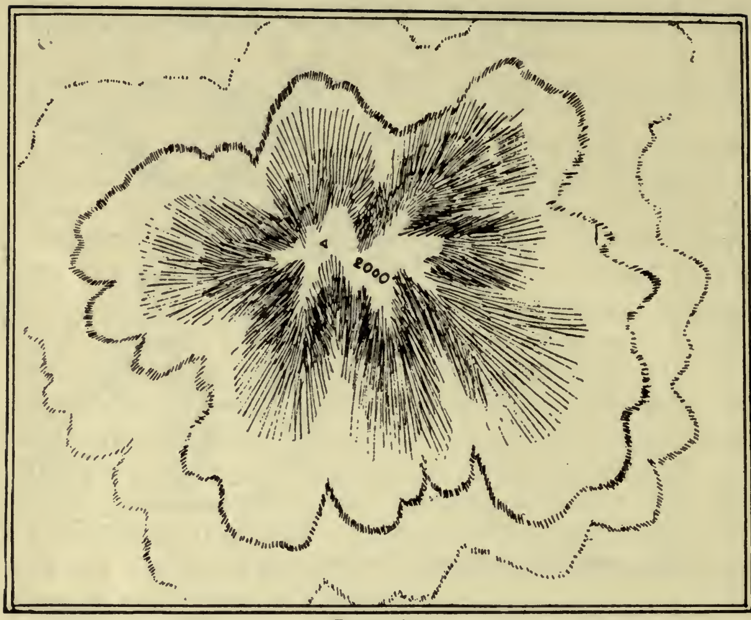
All officers and non-commissioned officers should be capable of readily making a hasty reconnaissance or outpost sketch, as such sketch accompanied by a written report will generally give more complete and clear information than can be conveyed by any written report alone. As the proximity of the enemy may prevent traversing, it will sometimes be necessary to make such a sketch from one station and with only a note book and pencil. The report to accompany the sketch (Diagram 7) might be about as follows:



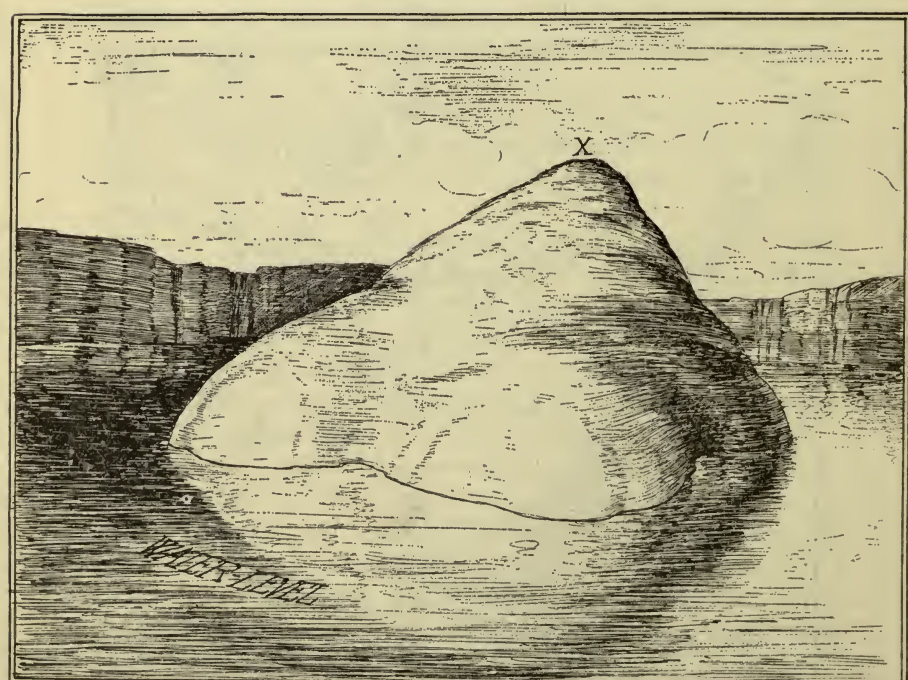
Diag. 26.



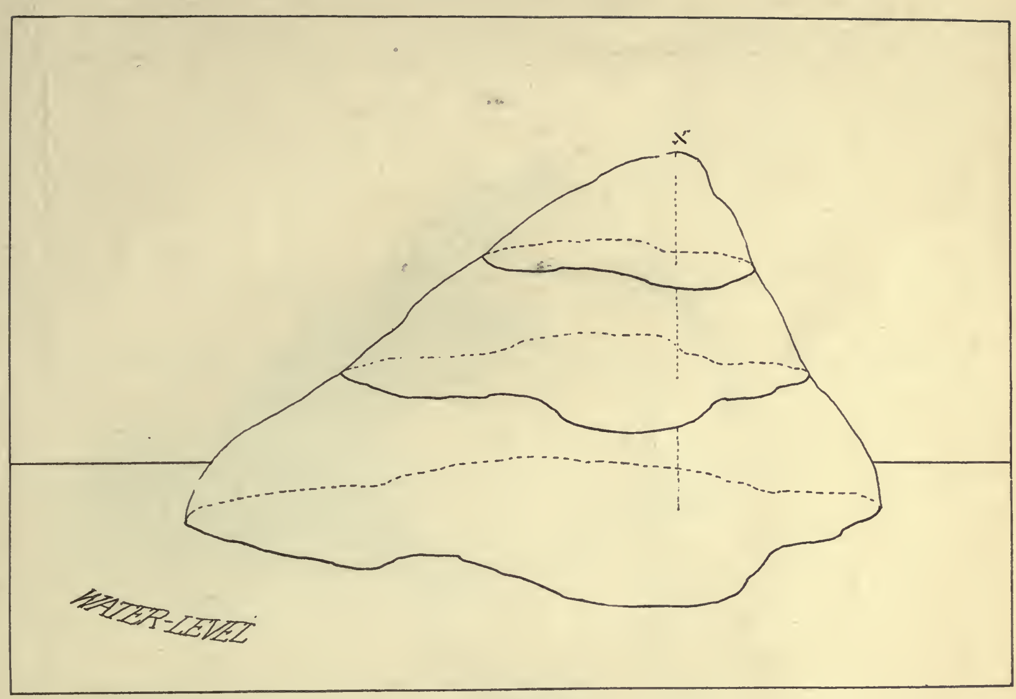
Diag. 25.



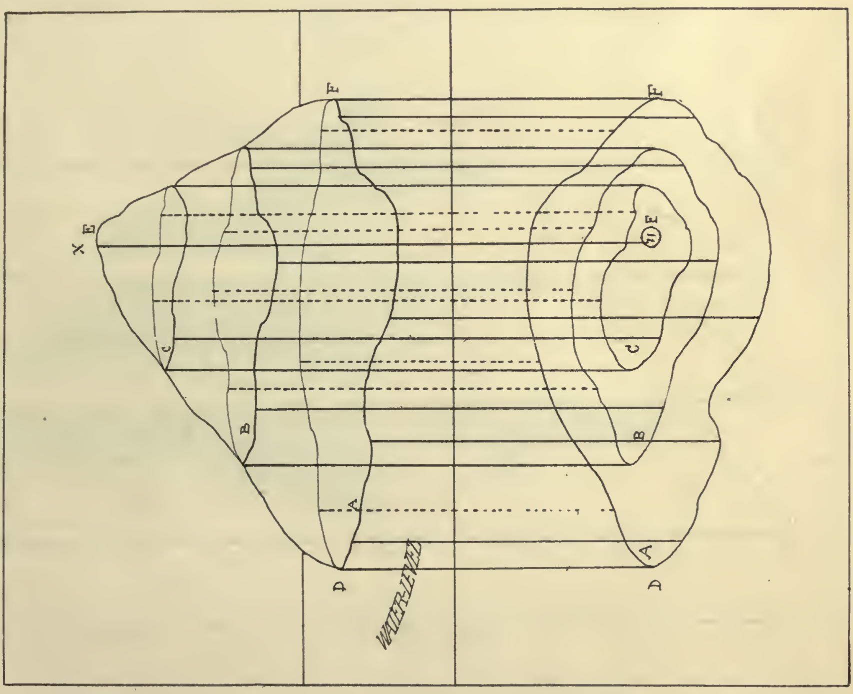
DIAG. 27.



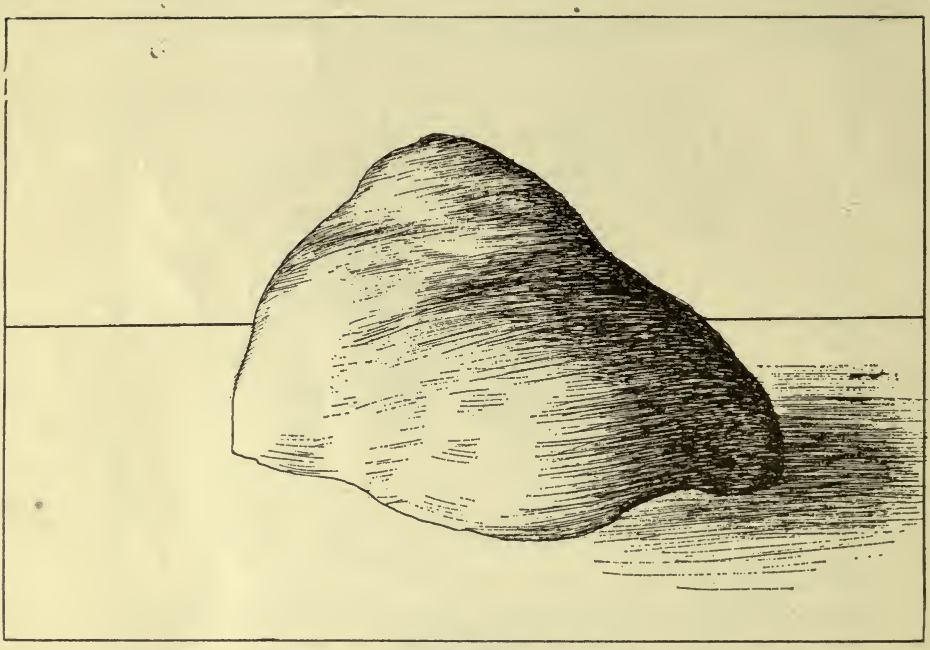
DIAG. 28.



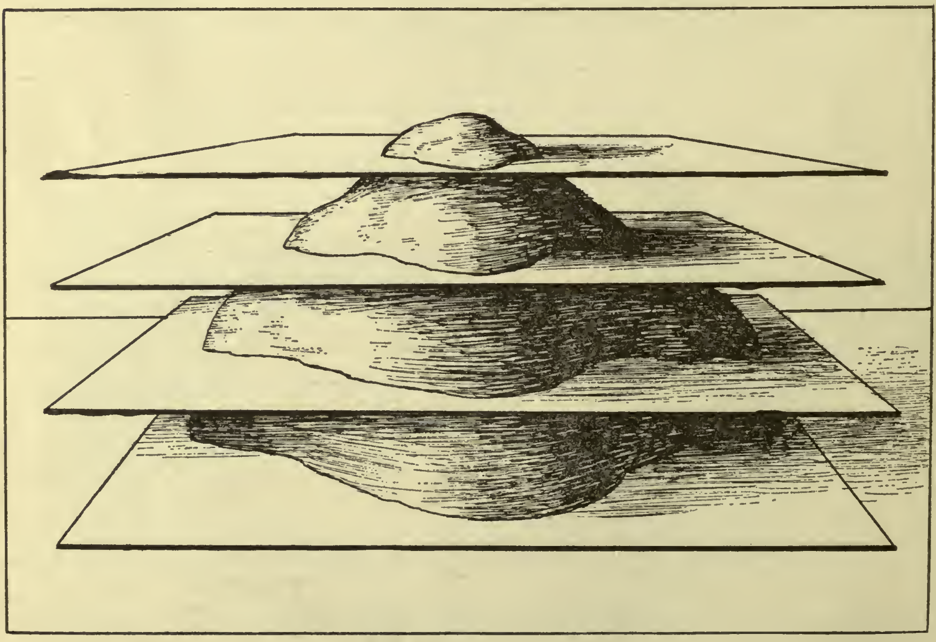
DIAG. 29.



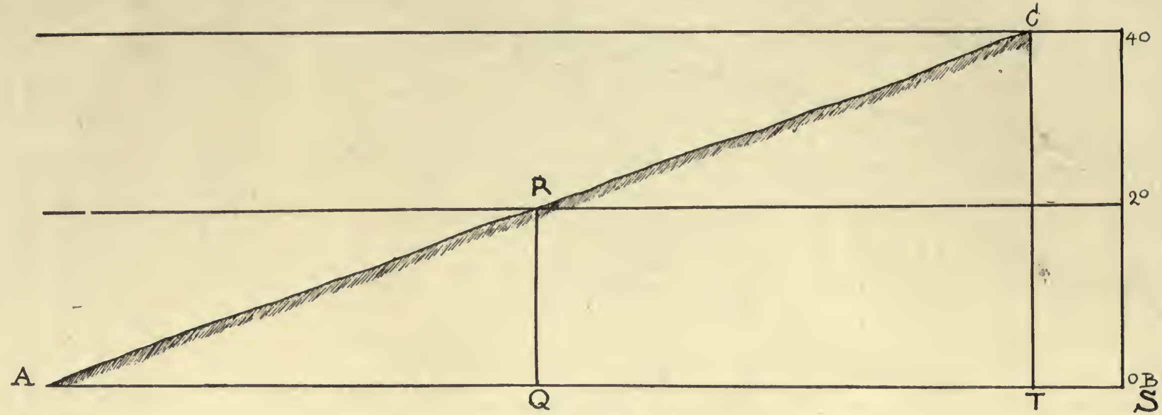
DIAG. 30.



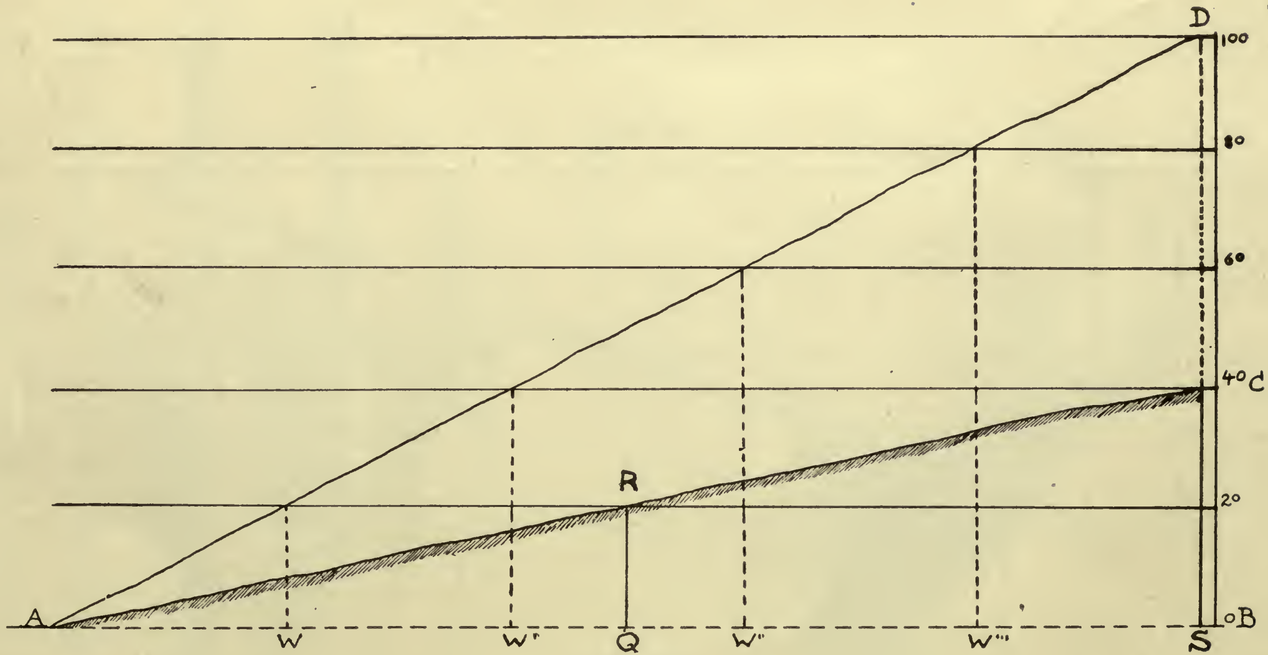
Diag. 31.



Diag. 32.



DIAG. 35.



DIAG. 35a.

"Station (1) and (2) are joined by an improved road; the bridge is guarded by a detachment of hostile troops; hostile sentries are posted along the edge of the wood on the north side of the river. The wood is thick and reaches as far as the village of Boxford. A body of our troops could easily win the fire-protection of the houses, which are generally of brick. The cultivated ground to the front affords no cover. Natives state that the river is fordable just west of the bridge."

CONTOURS AND CONTOURING.

12. CONTOURS are imaginary horizontal lines circumscribing elevations (or depressions) on the Earth's surface at equal vertical distances. The theory and application of contouring methods thus offer a means of representing, graphically, the forms of the ground.

The map-scale deals with horizontal distances (areas), while the contour deals with vertical distances, i. e., height or depth.

Before the principles of contouring were applied, ground forms were represented by means of "Hachures"—parallel dashes in the direction of the slope, shading-work with an effort to give plastic impression. (Diagram 27).

This method is not accurate and is rendered obsolete through the evident superiority of contouring.

How can the hill X be represented on a map? (Diagram 28).

In Diagram 29, a series of horizontal planes (with equal vertical distances) are passed through the hill X. (See diagram 32.)

It is apparent that the edge (a line) of each plane follows the form of the ground. (Diagram 30, upper half.)

These lines are called "CONTOURS", and the sum of their vertical distances is the total height of the elevation.

The lines are plotted by "horizontal projection;" that is, if perpendiculars are dropped from points along the edges of planes to the (lowest) base-plane (water level) and the projected points on the base-plane are then joined, a true picture of the corresponding plane is obtained. (Diagram 30 lower half).

13. By comparing the lower with the upper half (diagram 30) it is seen that the plotted contours are far apart along the

gradual slope D-E, while they close along the steeper slope F-E. The location of these contours is determined from the relation of ground distance to degree of slope, and involves a consideration of the meaning of the terms *Vertical Interval,* and *Map Distance.*

VERTICAL INTERVAL (V. I.) is the *vertical distance* (*i. e.* the difference in elevation) between adjacent contour planes. In the slope represented in diagram 35, the contour planes passing through the points *A, R, C,* are 20 feet, vertical distance, apart, (R-Q), and are said to have a V. I. of 20 feet.

The actual ground distance between A, and the first contour point is represented by A-R. A-Q is the horizontal projection of this ground distance and is called *Map Distance* (M. D.) when plotted to scale on the map. *Map Distance* is, therefore, the plotted *horizontal* or *level* distance between adjacent contours.

In diagram 35a, A-D and A-C, representing slopes of different degrees, have the same horizontal distance, A-S. Contours for the slope A-D would be plotted on the map at W, W,' W," W,'" and at S, while contours with the same V. I. for the slope A-C would be plotted at Q, and S only. The total horizontal distance is the same for each slope, but the Map Distances between contours on each slope are in reverse proportion to the degrees of slope: and,

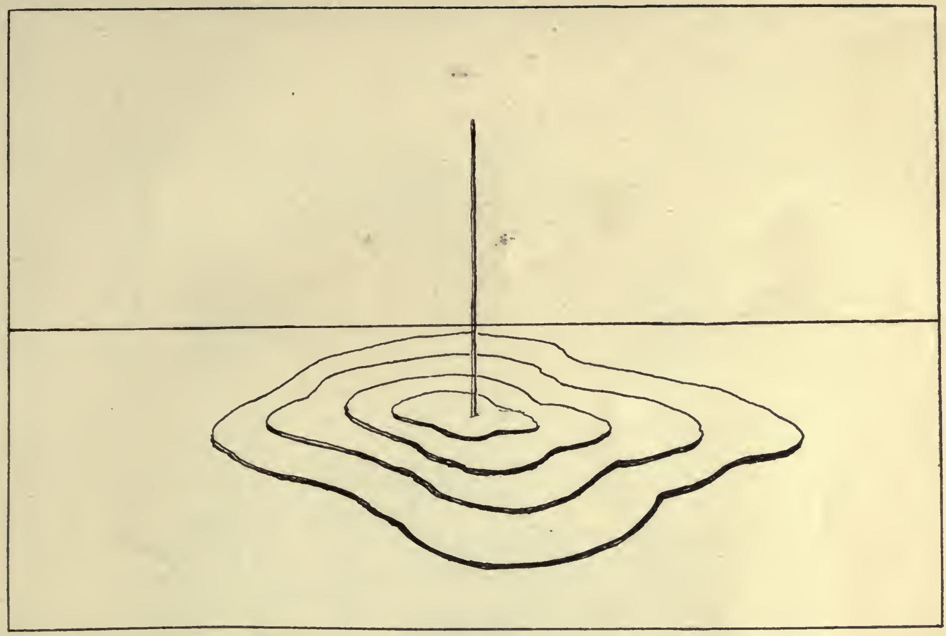
AW : AQ : : angle SAC : Angle SAD.

It is sufficient to know that on a 1° slope we will get an elevation of one foot in a horizontal distance of 57.3 feet. Therefore, we would get an elevation of 20 feet in a horizontal distance of 1146 feet (20x57.3), and on a 5° slope we would rise 20 feet in a horizontal distance of 229.2 feet (1146÷ 5), etc.

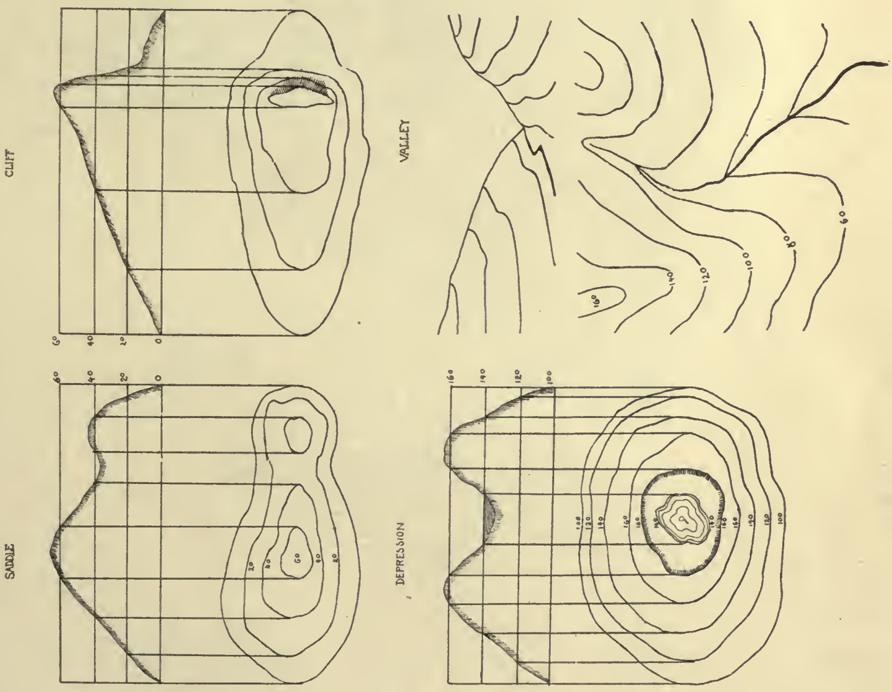
The M. D. for any degree of slope may be determined by the following formula:

$$\text{M. D.} = \frac{\text{V.I.x57.3}}{\text{Degree of slope.}} \text{ plotted to the scale of the map.}$$

In sketching, where time and instruments for measuring horizontal distances are usually not available, the actual *ground distances are plotted instead of the horizontal distances,* as would obtain in a survey.



Diag. 34.



Diag. 34a.

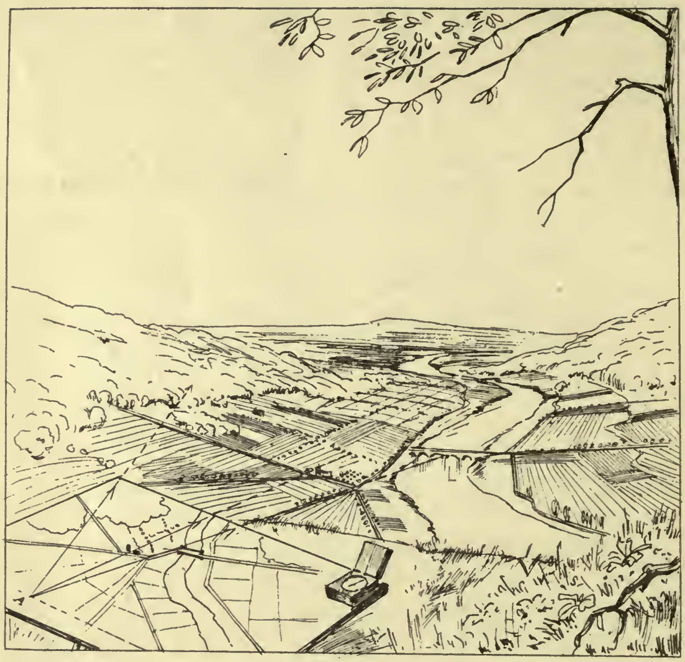
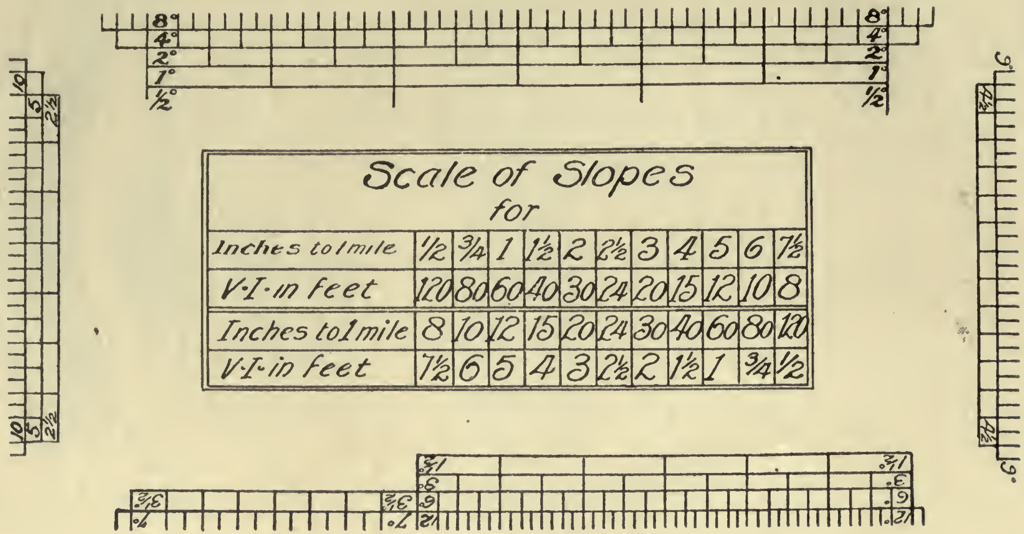


PLATE: A

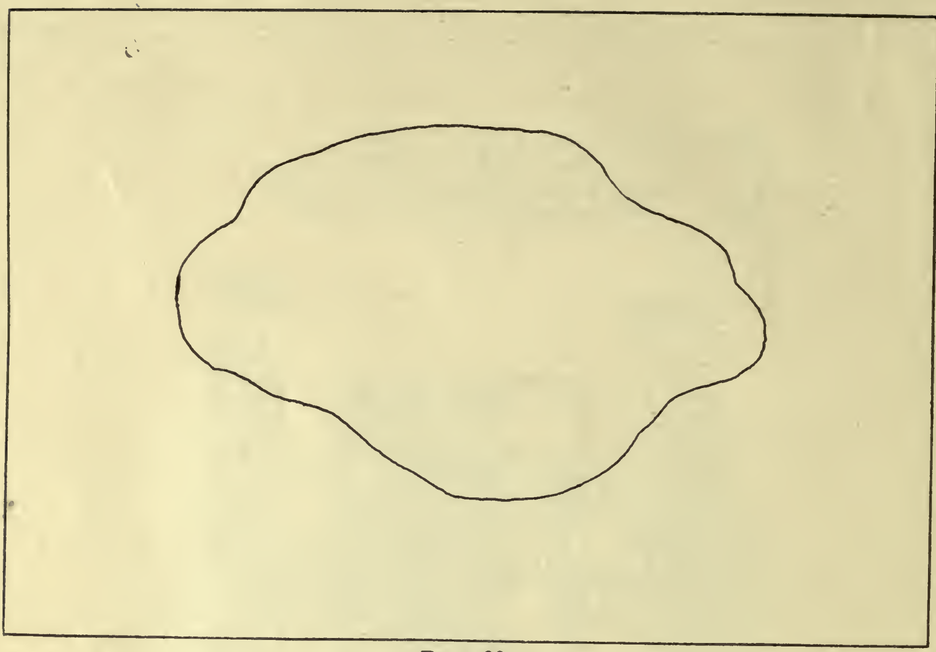
PLATE·B



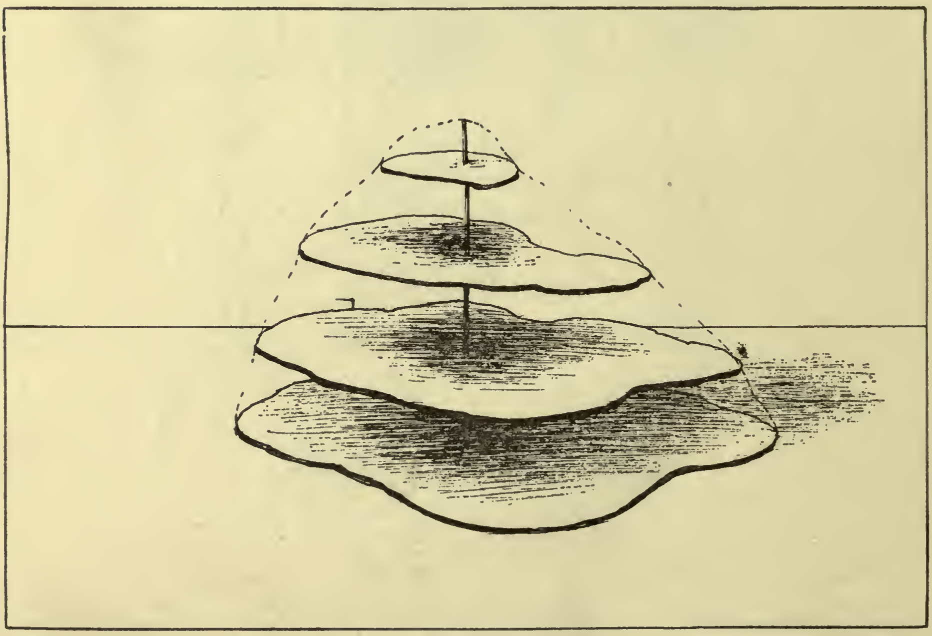
Scale of Slopes for

Inches to 1 mile	½	¾	1	1½	2	2½	3	4	5	6	7½
V·I· in feet	120	80	60	40	30	24	20	15	12	10	8
Inches to 1 mile	8	10	12	15	20	24	30	40	60	80	120
V·I· in feet	7½	6	5	4	3	2½	2	1½	1	¾	½

DIAG. 37.



Diag. 32a.



Diag. 33.

[*Note*: Map Distance is sometimes referred to as *Horizontal Equivalent* or H. E.]

To construct a scale of M. D., *plot the horizontal distance for the different degrees of slope to the scale of the map.* Diagram 36 shows a scale of M. D. for the map scale and V. I. indicated. A scale ½° to 10° will usually cover all cases. The Book Department, Service Schools, Fort Leavenworth, Kans., supplies a "slope card" (Diagram 37) giving M. D. for slopes from ½° to 10° for maps 3, 6, or 12 inches to the mile with corresponding contour intervals of 20, 10 or 5 feet.

15. A simple demonstration of the theory of contouring is the following: Of soft material (clay or sand) form a small irregular figure, giving it the shape of a hill: (Diagram 31).

Pass several horizontal planes (pasteboard) through this figure, carefully preserving an equal *vertical* interval between planes: (Diagram 32.)

Where a plane passes through the figure by outlining its shape with a pencil, an exact plotting of the form of the figure at this particular level will be obtained: (Diagram 32 a).

File these planes along a perpendicular axis (wooden-staff), preserving the original vertical interval between planes. (Diagram 33.)

To demonstrate "horizontal projection." the higher planes are moved along the axis to the lowest plane. (Diagram 34). A true map-picture of the hill is thus obtained.

Diagram 34a illustrates the manner of representing some characteristic ground forms.

16. In road or position sketching contours are located and plotted as are other features, slopes being measured or estimated, and slope card or scale of M. D. applied. If the elevation of the starting point above the datum or sea level, is not known, any elevation for the point may be assumed; further changes of level are relative to the assumed elevation of the starting point. As a matter of convenience, any assumed elevation should be some hundreds of feet 100, 500 or 1000, etc., a sufficient elevation being assumed to insure having no contour with a minus designation. For example, if starting a sketch with an assumed elevation of 100 feet, and later ground is encountered with an elevation of 120 feet *less* than the starting point, it would be necessary

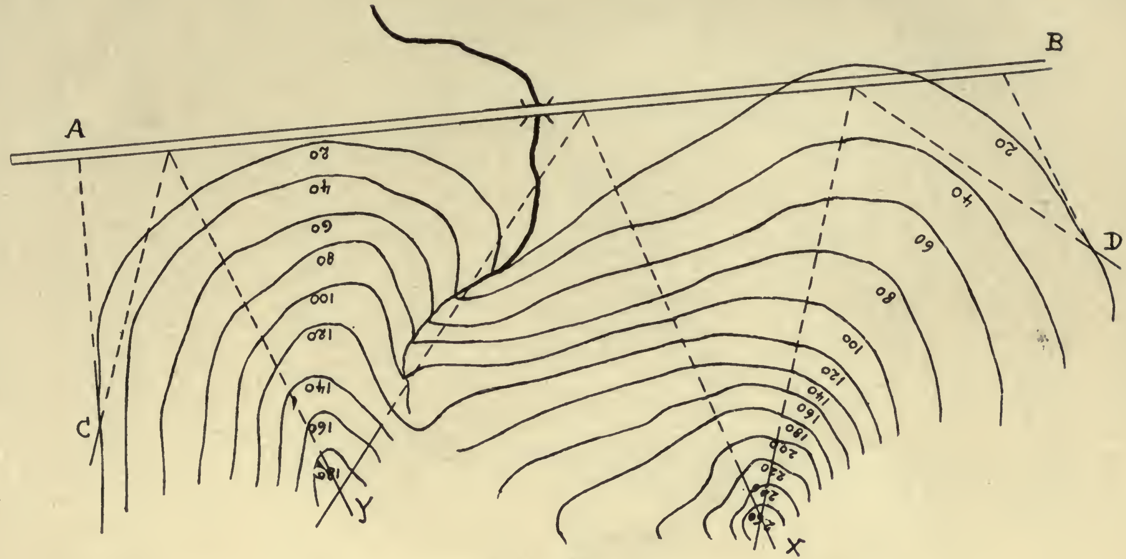
to number this lowest point (minus)—20 feet. This could have been avoided by assuming a greater elevation at the starting point, such as 500 feet. In sketching it must be understood that the exact determination of elevations of points above sea level is not usually essential, but that the value of contouring is in showing on the map the *relative* elevations of such points.

17. In Diagram 18a the reading of the slope board is + 4.° The hill is then said to have a slope of 4°; traverse (or estimate) the distance between points of sighting and the top of the hill, which is found to be 500 yards. Plot the point and apply the scale of M. D. (slope-card) on the ray to the hill to determine the number and location of contours. If the slope is not uniform, the number of contours (height of the hill) remains the same of course, but the exact *location* of the contour lines must be determined by estimation. As the steepness of slope varies in going from the sighting position to the top of the hill, the M. D. between adjacent contours must vary accordingly.

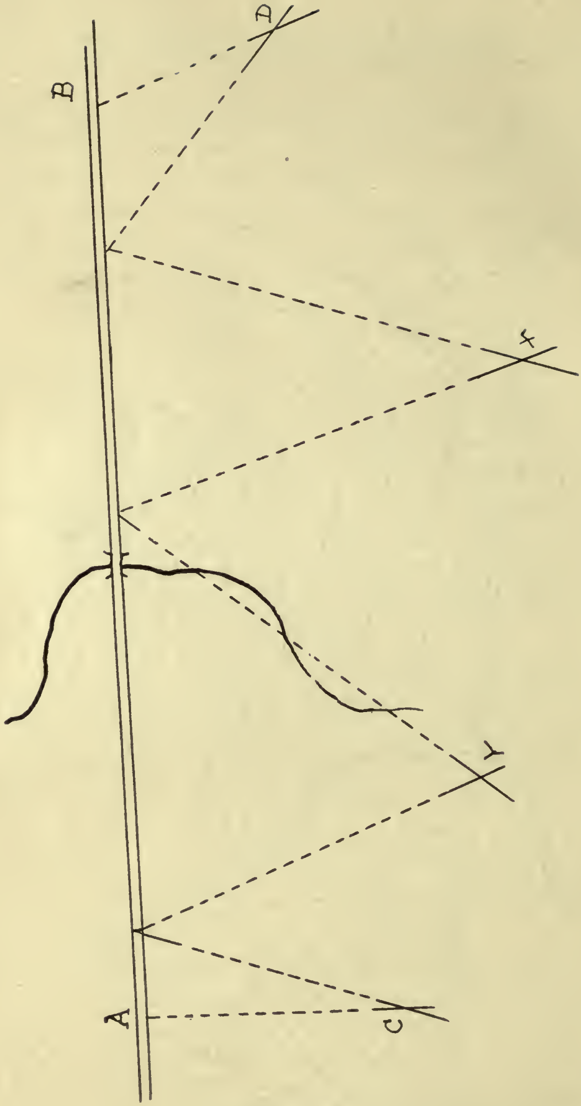
In Diagrams 38 and 38a a road (A-B) passes a hill. The highest points of the elevation (x and y), are located by intersection from the road. As the road is being traversed it is not difficult to determine the lowest points of the hill, that is, where the slope loses itself in the level of the road. Measure the slope to y and to x, from the two points. Apply the scale of M. D. for the determined degrees of slope along the plotted intersecting lines,—indicating the contour points. Plot contours through these points, tracing their intermediate course by estimation.

Points C and D may also be located by intersection.

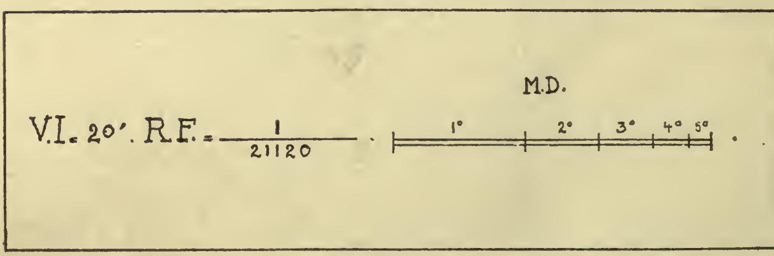
In order to contour a map *accurately*, precise angle measuring instruments (as a transit or "Y" level) should be used. Any other method will be more or less inaccurate. For rapid sketching, however, with an allowable error of 5%, a hand level, slope board, or *carefully trained estimation* will answer all purposes.



DIAG. 38a.



DIAG. 38.



DIAG. 36.

POSITION SKETCHING.

18. A *position sketch* or map, differs from a *road sketch* in that some complete area is shown instead of only a road and the features near it, (Plates A and B.)

The ordinary military map is an example of a position map of an extended area made with accurate instruments, and involving considerable time in its preparation. Position sketches must usually be expeditiously made and may range in accuracy from the crudest outpost sketch to a correct map. Position sketches are of importance to show unmapped areas of prospective battle fields, camp sites, etc., and may thus be of great military value to a commander.

In making a position sketch, the first endeavor is to plot on the paper the locations of prominent lines and points of possible military value such as railroads, roads, long fences, important streams and water courses, spires, woods, houses, prominent hill tops, and sometimes single trees which might help to locate important ground forms or topography near them.

These lines, points and features are located by base line methods and by traversing. A *base line* is a traverse (or measured course) as from A to B, (Plate B) on which are two or more points from which interesections can be made to locate other prominent features. Base lines and traverses are measured by striding and are plotted as carefully as possible. Base lines need not be *in one* straight line, necessarily, but with an irregular base line or traverse more care is required than when working from a single straight line.

On the sketch in Plate B, the forks of the roads, trees at the edge of the timber, and the bridge have been located by intersection from the base line A-B. The line A-B was selected because points A and B locate important ground, also the distance A-B could be measured by striding, and because other points and lines could be located from A and B or from points on the line A-B.

To locate other points or lines, as the bank of the stream to the northeast, draw a ray or line toward the bank. The distance may be obtained by counting the strides to that point.

The points and lines, referred to above, when plotted on the paper, given a network for the sketch called "control," over the area. After this control is obtained, the topography, that is, the contours for ground forms, the cultivation, small ravines, trees, houses, etc. can be filled in rapidly because each such feature is near a point or line already located on the sketch.

Sometimes sketchers fill in the topography near each point, while oriented at that point, before proceeding further.

The elevation of the base line is known or assumed and slopes having been determined by slope board or hand level, the contours for the ground form may be plotted directly, or the degrees of slope to intersected points may be indicated on rays to those points, (control) and the contours plotted as described in paragraph 17.

19. A theoretical knowledge of sketching will not, without considerable practical application, make one a proficient sketcher. Military sketches to be of value must usually be made rapidly and with reasonable accuracy. In road sketching, for example, the sketcher would generally be with the independent cavalry, and must keep up with it from day to day, sending back the completed road sketch each night. Experience will show the sketcher a way to many short cuts; for example, estimating the slope (or number of contours) between points, estimating distance to features off the road, skill in rapid orientation and actual drawing, and an "eye for ground" in contouring.